Attorney Docket No. SEL 209

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:)
)
Jun Koyama)
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Serial No: 09/666,521)
)
Filed: September 20, 2000)
)
Examiner: Kimhung T. Nguyen)
)
Art Unit: 2629)
)
Confirmation No.: 6933)
)
For: EL DISPLAY DEVICE AND)
ELECTRONIC DEVICE)

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

TRANSMITTAL OF VERIFIED ENGLISH TRANSLATION OF PRIORITY DOCUMENT

Dear Sir:

In furtherance of Amendment K filed on September 23, 2008, Applicant is submitting herewith a verified English translation of the priority document Japanese patent application serial number 11-271235 filed September 24, 1999 in Japan.

In the Office Action of June 23, 2008, the Examiner had the following rejections under 35 USC §103(a):

1. Claims 1-3, 9-12, 18-22 and 28-31 are rejected as being unpatentable over Yamada et al. (US 5,990,629) in view of Shioya et al. (US 6,091,382) in view of von Stein et al. (US 6,529,243).

2. Claims 7, 16, 26 and 35 are rejected as being unpatentable over Yamada et al. and Shioya and von Stein et al. in view of Yamazaki et al. (US 6,388,652).

3. Claims 8, 17, 27 and 36 are rejected as being unpatentable over Yamada et al. and Shioya et al. and von Stein et al. in view of Yamazaki et al. '652 and further in view of Yamazaki et al. (US 6,445,005).

4. Claims 4, 13, 23 and 32 are rejected as being unpatentable over Yamada et al. and Shioya et al. and von Stein et al. in view of Yamazaki et al. '652 and further in view of Choi et al. (US 6,583,577).

While Applicant respectfully traversed these rejections, in Amendment K, Applicant amended independent Claims 1, 9, 19, and 28 to recite the features previously recited in dependent Claims 4, 13, 23, and 32 (which were then canceled).

As the Examiner admitted in the Office Action (in the rejection of Claims 4, 13, 23 and 32 whose features are now incorporated into the independent claims), neither Yamada, Shioya, von Stein, nor Yamazaki et al. '652 disclose the added features of independent Claims 1, 9, 19 and 28.

The Examiner, however, cited Choi as allegedly disclosing these claimed features. As explained below, Choi is not prior art to the present application.

More specifically, Choi issued on June 24, 2003 based on a U.S. filing date of August 18, 2000.

The present application was filed on September 20, 2000 and claims priority under 35 USC §119 of Japanese patent application serial number 11-271235 filed September 24, 1999 in

Japan. A certified copy of this priority Japanese application was filed September 20, 2000 in the present U.S. application.

Applicant is submitting herewith a verified English translation of Japanese patent application serial number 11-271235. Therefore, Applicant is entitled to claim the benefit of the September 24, 1999 filing date of this priority application.

Hence, as the §119 priority filing date of the present application is prior to the U.S. filing date of Choi, Choi is not prior art to the present application.

Accordingly, for at least the above-stated reasons, it is respectfully requested that these rejections be withdrawn.

Conclusion

It is respectfully submitted that the present application is in a condition for allowance and should be allowed.

Please charge our deposit account 50/1039 for any fee due for this submission.

Favorable reconsideration is earnestly solicited.

Date: October 15, 2008

Respectfully submitted,

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For: EL DISPLAY DEVICE AND	)
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VERIFICATION OF TRANSLATION

Commissioner for Patents
P.O.Box 1450
Alexandria, VA 22313-1450

Dear Sir:

I, Junko Kato, C/O Semiconductor Energy Laboratory Co., Ltd. 398, Hase, Atsugi-shi, Kanagawa-ken 243-0036 Japan, a translator, herewith declare:

that I am well acquainted with both the Japanese and English Languages;

that I am the translator of the attached English translation of the Japanese Patent Application No. 11-271235 filed on September 24, 1999; and

that to the best of my knowledge and belief the following is a true and correct English translation of the Japanese Patent Application No. 11-271235 filed on September 24, 1999.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Date: this 14th day of October, 2008

Junko Kato

Name: Junko Kato

[Name of Document] Patent Application

[Reference Number] P004361-02

[Filing Date] September 24, 1999

[Attention] Commissioner, Patent Office Takahiko KONDO

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[Identification of Handlings]

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[List of Attachment]

[Attachment]	Specification	1
[Attachment]	Drawing	1
[Attachment]	Abstract	1

[Proof] Required

[Name of Document] Specification

[Title of Invention] EL DISPLAY DEVICE AND ELECTRONIC DEVICE

[Scope of Claims]

[Claim 1]

An electronic device characterized by comprising:

an EL display device having a TFT, a pixel electrode electrically connected to the TFT, an EL element with the pixel electrode as a cathode or an anode, and an insulating layer for sealing the EL element;

a means for applying an analog image signal to the EL element; and

a means for gamma correcting the analog image signal.

[Claim 2]

The electronic device according to claim 1, characterized by comprising a memory for storing data for the gamma correction.

[Claim 3]

The electronic device according to claim 1 or claim 2, characterized in that a color filter is formed at a position corresponding to the pixel electrode.

[Claim 4]

The electronic device according to claim 1 or claim 2, characterized in that the EL element comprises a first pixel having a blue light emitting layer, a second pixel having a green light emitting layer, and a third pixel having a red light emitting layer.

[Claim 5]

The electronic device according to any one of claims 1 to 4, characterized in that the gamma correction is to amplify a signal of red

[Claim 6]

The electronic device according to any one of claims 1 to 4, characterized in

that the gamma correction is to attenuate a signal of blue or green.

[Claim 7]

The electronic device according to any one of claims 1 to 4, characterized in that the gamma correction is performed independently for each of signals of blue, green and red.

[Claim 8]

The electronic device according to any one of claims 1 to 7, characterized in that the EL element has a light emitting layer made of a polymer organic material.

[Claim 9]

An EL display device characterized by comprising on the same substrate:

a TFT;

a pixel electrode electrically connected to the TFT;

an EL element with the pixel electrode as a cathode or an anode;

an insulating layer for sealing the EL element;

a means for applying an analog image signal to the EL element; and

a means for gamma correcting the analog image signal.

[Claim 10]

The EL display device according to claim 9, characterized by comprising a memory for storing data for the gamma correction.

[Claim 11]

An electronic device characterized by using the EL display device according to claim 9 or claim 10.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Pertains]

The present invention relates to an EL (electroluminescence) display device formed by a semiconductor element (an element using a semiconductor thin film, typically a thin film transistor) built on a substrate, and to an electronic device having the EL display device as a display portion.

[0002]

[Prior Art]

A technology of forming a thin film transistor (hereafter referred to as a TFT) on a substrate has greatly advanced in recent years, and development of applications to active matrix display devices is proceeding. In particular, a TFT using a polysilicon film has a higher electric field effect mobility than a TFT using a conventional amorphous silicon film, and therefore it is capable of high speed operation. Accordingly, control of a pixel, which has been conventionally performed by a driver circuit external to a substrate, can be performed by a driver circuit formed on the same substrate as the pixel.

[0003]

This type of active matrix display device is gaining attention for obtaining many advantages, such as lowered manufacturing cost, smaller display device, increased yield, and reduced throughput, by building various circuits and elements on the same substrate.

[0004]

In recent years, research on active matrix EL display devices having EL elements as self-light emitting elements has been activated. The EL display device is also referred to as an organic EL display (OELD) or an organic light emitting diode (OLED).

[0005]

The EL display device is of a self-emission type which differs from a liquid crystal display device. The EL element has a structure in which an EL layer is

sandwiched between a pair of electrodes, and the EL layer generally has a laminated structure. A laminated structure of 'a hole transporting layer / a light emitting layer / an electron transporting layer' proposed by Tang, et al., of Eastman Kodak Co. can be given as a typical structure. This structure has extremely high light emitting efficiency, and nearly all EL display devices which have been researched and developed employ this structure.

[0006]

Furthermore, other structures such as a hole injecting layer / a hole transporting layer / a light emitting layer / an electron transporting layer, or a hole injecting layer / a hole transporting layer / a light emitting layer / an electron transporting layer / an electron injecting layer formed in order on a pixel electrode may also be used. The EL layer may be doped with a fluorescent pigment.

[0007]

A predetermined voltage is then applied to the EL layer having the above structure from a pair of electrodes, whereby recombination of a carrier occurs in the light emitting layer, and thus light is emitted.

[0008]

[Problems to be Solved by the Invention]

The EL display device has roughly four colorizing display systems: a system in which an EL element of white light emission and color filters are combined; a system in which three kinds of EL elements corresponding to R (red), G (green) and B (blue) are formed; a system in which an EL element of blue or blue-green light emission and a fluorescent material (fluorescent color converting layer: CCM) are combined; and a system in which a transparent electrode is used as a cathode (counter electrode) and EL elements corresponding to RGB are overlapped.

[0009]

The color filter is a color filter for extracting light of red, green or blue. Such a color filter is formed at a position corresponding to a pixel, and this makes it possible to change the color of extracted light at each pixel. This is the same in principle as a colorizing system of a liquid crystal display device using color filters. Note that the position corresponding to the pixel indicates a position coincident with a pixel electrode.

[0010]

However, the color filter is a filter which extracts the light of a specified wavelength to improve the color purity of the transmitted light. Thus, in the case where there are few light components of a wavelength to be extracted, such a disadvantage may occur that the luminance of light of the wavelength is extremely low or the color purity is poor.

[0011]

In known organic EL materials, red light with high luminance has not been realized, and like an example shown in FIG. 10, the luminance of red light is low as compared to the luminance of blue and green light. In the case where an organic EL material having such luminescent characteristics is used for an EL display device, the luminance of red light of an image to be displayed becomes poor.

[0012]

Furthermore, a method of using orange light having a slightly lower wavelength than that of red light has been conventionally performed because the luminance of red light is low as compared to the luminance of blue and green light. However, also in this case, the luminance of a red color image which is displayed by an EL display device is low, and when the red color image is attempted to be displayed, it is displayed as orange.

[0013]

In consideration of the above, it is an object to provide an EL display device for displaying an image which has a desirable good balance between red, blue, and green in EL elements with different luminance of red, blue and green light.

[0014]

[Means for Solving the Problems]

A structure of the invention disclosed in this specification is an electronic device characterized by including an EL display device having a TFT, a pixel electrode electrically connected to the TFT, an EL element with the pixel electrode as a cathode or an anode, and an insulating layer for sealing the EL element; means for applying an analog image signal to the EL element; and means for gamma correcting the analog image signal.

[0015]

The above structure may be a structure including a memory for storing data for the gamma correction.

[0016]

Another structure of the invention is an EL display device characterized by including on the same substrate, a TFT; a pixel electrode electrically connected to the TFT; an EL element with the pixel electrode as a cathode or an anode; an insulating layer for sealing the EL element; means for applying an analog image signal to the EL element; and means for gamma correcting the analog image signal.

[0017]

The above structure may be a structure further including a memory for storing data for the gamma correction on the same substrate.

[0018]

Furthermore, in the above EL display device, a color filter is formed for

colorization at a position corresponding to the pixel electrode.

[0019]

Furthermore, for colorization by using another method, the EL element may be formed of a first pixel including a blue light emitting layer, a second pixel including a green light emitting layer, and a third pixel including a red light emitting layer. In this case, the color filter may be used or may not be used.

[0020]

Furthermore, in the above EL display device, the gamma correction may be to amplify a signal of red, or may be to attenuate a signal of blue or green. Furthermore, the gamma correction may be performed independently for each of signals of blue, green and red.

[0021]

By adopting the foregoing structure, even in the case of using an EL material which has a few red light components of a wavelength to be extracted by the color filter, it is possible to provide an EL display device displaying an image having a desirable good balance between RGB (red, blue, green) by performing the gamma correction of, for example, a video signal to adjust the luminance of RGB (red, blue, green) light.

[0022]

[Embodiment Mode of the Invention]

An embodiment mode of the present invention is described below with reference to FIG. 1 and FIG. 2.

[0023]

FIG. 1 is a block diagram showing an EL display device of the present invention. In FIG. 1, reference numeral 100 denotes an active matrix substrate which includes source driver circuits 110 and 120, a gate driver circuit 130, and a pixel portion 150. The pixel

portion 150 includes pixels arranged in matrix form, and each pixel includes a TFT 151, an EL element 152, and the like. Note that although not shown for simplification, colorization is realized in this embodiment by using color filters corresponding to R (red), G (green) and B (blue).

[0024]

Reference numeral 160 denotes an image signal processing circuit which includes an A/D conversion circuit 163 for converting an analog signal inputted from the outside into a digital signal, a correction circuit 161 for correcting the digital signal, and a D/A conversion circuit 164 for converting the corrected digital signal into an analog signal. The correction circuit 161 includes a correction memory 162. In the display device of the present invention, a video signal 200 is gamma corrected. For example, the video signal 200 is corrected on the basis of a gamma correction table stored in the correction memory.

[0025]

A control circuit 170 controls various signals supplied to the active matrix substrate 100 and the image signal processing circuit 160. A synchronous signal 210 is inputted to the control circuit 170.

[0026]

Furthermore, the control circuit 170 is a circuit for generating and supplying pulses (a start pulse, a clock pulse, a synchronous signal, and the like) necessary for controlling the operation timing of the source driver circuits 110 and 120, the gate driver circuit 130, the image signal processing circuit 160, and the like on the basis of the synchronous signal 210.

[0027]

Note that the control circuit 170 repeats an operation (frequency division) for

counting a previously set count number (frequency division ratio) of clocks, while the inputted synchronous signal 210 is used as a reference and an oscillation clock signal (OSC) outputted from a phase synchronized oscillator is used as an original oscillation. The clocks are counted at the same time as this frequency division to generate a start pulse (S_SP) and a clock pulse (S_CK) in the horizontal direction of a screen, which are supplied to the source driver circuit, a start pulse (G_SP) and a clock pulse (G_CK) in the vertical direction of a screen, which are supplied to the gate driver circuit, a clock pulse (D_CK), and the like. In addition, there is also a case where a horizontal synchronous signal (HSY) and a vertical synchronous signal (VSY) are generated.

[0028]

The image signal processing circuit 160, the control circuit 170, and the like are mounted on a substrate different from the active matrix substrate 100, for example, another printed substrate, and circuits on the substrate and the active matrix substrate 100 are connected through a cable, a flexible wiring board, or the like. Note that it is needless to say that such a structure is preferably employed that part or all of circuits such as the image signal processing circuit 160 and the control circuit 170 are provided on the same substrate as the active matrix substrate since integration and miniaturization are realized.

[0029]

The video signal 200 inputted to the image signal processing circuit 160 from the outside is an analog signal. The video signal 200 may be an analog signal such as a television signal or a video signal, or may be an analog signal obtained by D/A converting a data signal from a computer or the like.

[0030]

In the image signal processing circuit 160, the video signal 200 is converted into

a digital video signal by the A/D conversion circuit 163 and is outputted to the correction circuit 161. On the basis of the gamma correction table stored in the correction memory, the correction circuit 161 performs gamma correction of the inputted digital video signal in view of the luminance of each EL element.

[0031]

In the gamma correction, a supplied image signal is corrected in order to obtain excellent gradation display. The gamma corrected digital video signal is converted into an analog video signal by the D/A conversion circuit 164 and is supplied to the source driver circuits 110 and 120.

[0032]

By this correction circuit 161, a video signal supplied to each EL element is gamma corrected, and the luminance of each of blue light emission, green light emission and red light emission can be appropriately controlled in accordance with the voltage and current of the corrected analog video signal. For example, in the case of using an EL element using three kinds (R, G, B) of color filters as shown in FIG. 10, the video signal (corresponding to R) has only to be gamma corrected to increase the luminance of R so that the luminance of each color becomes the same. Alternatively, the video signal applied to the EL element (corresponding to B or G) has only to be gamma corrected to decrease the luminance of B or G so that the luminance of each color becomes the same. In addition, the video signals applied to the respective EL elements may be gamma corrected to increase the luminance of R and to decrease the luminance of B or G so that the luminance of each color becomes the same.

[0033]

Here, description is made on an example of a method for generating the gamma correction table of the correction memory in the correction circuit in the image signal

processing circuit 160 of the present invention.

[0034]

Reference will be made to FIG. 2. FIG. 2 is a circuit block diagram in the case of generating the gamma correction table of the correction memory in the correction circuit in the image signal processing circuit 160 of the present invention. Reference numeral 201 denotes an image pickup device which converts an image displayed by the light emission of an EL element into an electric signal.

[0035]

As the image pickup device 201, another image pickup device such as a CCD camera or a digital video camera can be used. Alternatively, a luminance meter or an illuminance meter for merely measuring the lightness or brightness of a displayed image may be used. In the case where the luminance meter or the illuminance meter is used, an A/D conversion circuit for converting a signal supplied from these devices into a digital signal may be used.

[0036]

Reference numeral 202 denotes a digital signal processor (DSP); 203, a reference signal supply source; and 204, a signal generator (SG).

[0037]

The correction circuit 161 in the image signal processing circuit 160 performs gamma correction of a digital signal supplied from the signal generator 204, outputs the corrected digital video signal, converts the signal into an analog video signal by the D/A conversion circuit, and sends it to the respective EL elements. The respective EL elements emit light on the basis of the analog video signal supplied from the image signal processing circuit 160 and display an image.

[0038]

The displayed image is converted into a digital signal by using the image pickup device 201. The digital signal sent from the image pickup device 200 is supplied to the digital signal processor (DSP) 202. The digital signal processor 202 compares the digital signal supplied from the image pickup device 201 with a digital signal supplied from the reference data supply source 203, and feeds back the discrepancy between the data to the correction circuit 161. Note that the reference data may be directly supplied from the signal generator 204.

[0039]

In accordance with the signal supplied from the digital signal processor 202, the correction circuit 161 further corrects the digital signal from the signal generator 204, converts it into an analog video signal, and sends it again to the EL elements. The respective EL elements emit light on the basis of the analog video signal supplied from the image signal processing circuit 160 and display an image.

[0040]

The displayed image is again converted into a digital signal by using the image pickup device 201. The digital signal supplied from the image pickup device 201 is sent to the digital signal processor 202. The digital signal processor 202 compares the digital signal supplied from the image pickup device 201 with the digital signal supplied from the reference data supply source 203, and feeds back the discrepancy to the correction circuit 161.

[0041]

When appropriate gamma correction data is obtained in this way, the data is stored in the address specified by the correction memory 162.

[0042]

Subsequently, in order to start the correction of the next video signal, the signal

generator 204 sends a digital signal different from the previous one to the correction circuit 161. When appropriate gamma correction data corresponding to the digital signal is obtained, the data is stored in the address specified by the correction memory 162.

[0043]

When all correction data is stored in the correction memory 162, the signal generator 204 and the digital signal processor 202 are separated from the active matrix substrate 100. Here, the generation of the gamma correction table is completed. Note that it is needless to say that the method for generating the gamma correction table shown here is merely an example, and is not particularly limited. Besides, the block circuit diagram shown in FIG. 1 is also an example, and it is also possible to perform gamma correction by using, for example, a correction circuit without a correction memory.

[0044]

Subsequently, a digital video signal is supplied to the correction circuit 160, and on the basis of the data of the gamma correction table stored in the correction memory 161, the digital video signal is corrected and further converted into an analog video signal, and then supplied to the EL element. Since the analog video signal supplied to the EL element is appropriately corrected by the correction circuit 160, balanced light emission (red light emission, green light emission and blue light emission) is obtained and an excellent image is displayed.

[0045]

The present invention having the above structure is described below in more detail with reference to the following embodiments.

[0046]

[Embodiments]

[Embodiment 1]

In this embodiment, an EL display device provided with a correction circuit is described with reference to FIG. 1.

[0047]

FIG. 1 is a block diagram showing an EL display device of this embodiment. In FIG. 1, reference numeral 100 denotes an active matrix substrate which includes source driver circuits 110 and 120, a gate driver circuit 130, and a pixel portion 150. The pixel portion 150 includes pixels arranged in matrix form, and each pixel includes a TFT 151, an EL element 152, and the like. Note that although not shown for simplification, colorization is realized in this embodiment by using color filters corresponding to R (red), G (green) and B (blue).

[0048]

Reference numeral 160 denotes an image signal processing circuit which includes an A/D conversion circuit 163 for converting an analog signal inputted from the outside into a digital signal, a correction circuit 161 for gamma correcting the digital signal, and a D/A conversion circuit 164 for converting the gamma corrected digital signal into an analog signal. The correction circuit 161 includes a correction memory 162.

[0049]

Reference numeral 170 denotes a control circuit which controls various signals supplied to the active matrix substrate 100 and the image signal processing circuit 160. A synchronous signal 210 is inputted to the control circuit 170.

[0050]

The image signal processing circuit 160, the control circuit 170, and the like are mounted on a substrate different from the active matrix substrate 100, for example, another printed substrate, and circuits on the substrate and the active matrix substrate 100

are connected through a cable, a flexible wiring board, or the like.

[0051]

A video signal 200 inputted to the image signal processing circuit 160 from the outside is an analog signal such as a television signal or a video signal.

[0052]

In the image signal processing circuit 160, the video signal 200 is converted into a digital video signal by the A/D conversion circuit 163 and is outputted to the correction circuit 161. On the basis of the gamma correction table stored in the correction memory, the correction circuit 161 performs gamma correction of the inputted digital video signal in view of the luminance of each EL element. The gamma-corrected digital video signal is converted into an analog video signal by the D/A conversion circuit 164 and is supplied to the source driver circuits 110 and 120.

[0053]

The digital video signal is supplied to the correction circuit 160, and on the basis of the data of the gamma correction table stored in the correction memory 161, the digital video signal is gamma corrected and further converted into an analog video signal, and then supplied to the EL element. Since the analog video signal supplied to the EL element is appropriately gamma corrected by the correction circuit 160, balanced light emission (red light emission, green light emission and blue light emission) is obtained and an excellent image is displayed.

[0054]

Next, a method for manufacturing the EL display device of this embodiment is described with reference to FIG. 3 to FIG. 5. Note that in order to simplify the description, a CMOS circuit is shown as a basic circuit for the driver circuits.

[0055]

First, as shown in FIG. 3A, a base film 301 is formed to a thickness of 300 nm on a glass substrate 300. Silicon nitride oxide films are laminated as the base film 302 in this embodiment. At this time, a film in contact with the glass substrate 300 may have a nitrogen concentration of 10 to 25 wt%.

[0056]

Next, an amorphous silicon film (not shown) with a thickness of 50 nm is formed on the base film 301 by a known deposition method. Note that it is not necessary to limit to the amorphous silicon film, and a semiconductor film having an amorphous structure (including a microcrystalline semiconductor film) may be acceptable. In addition, a compound semiconductor film having an amorphous structure, such as an amorphous silicon germanium film, may also be used. Furthermore, the film thickness may be 20 to 100 nm.

[0057]

The amorphous silicon film is then crystallized by a known technique, thereby forming a crystalline silicon film (also referred to as a polycrystalline silicon film or a polysilicon film) 302. As known crystallization methods, there are a thermal crystallization method using an electric furnace, a laser annealing crystallization method using laser light, and a lamp annealing crystallization method using infrared light. In this embodiment, crystallization is performed by using excimer laser light which uses XeCl gas.

[0058]

Note that pulsed excimer laser light processed into a linear shape is used in this embodiment; however, a rectangular shape may also be used, and continuous wave argon laser light or continuous wave excimer laser light can also be used.

[0059]

Although the crystalline silicon film is used as an active layer of a TFT in this embodiment, it is also possible to use an amorphous silicon film. Alternatively, the amorphous silicon film may be used as an active layer of a switching TFT which needs to have a decreased off current, while the crystalline silicon film may be used as an active layer of a current controlling TFT. Current flows with difficulty in the amorphous silicon film because of low carrier mobility, and the off current does not flow easily. In other words, it is possible to take the advantages of both the amorphous silicon film, through which current does not flow easily, and the crystalline silicon film, through which current easily flows.

[0060]

Next, as shown in FIG. 3B, a protective film 303 made of a silicon oxide film is formed to a thickness of 130 nm on the crystalline silicon film 302. This thickness may be selected within the range of 100 to 200 nm (preferably 130 to 170 nm). Furthermore, other films may also be used as long as they are insulating films containing silicon. The protective film 303 is provided so that the crystalline silicon film is not directly exposed to plasma during addition of an impurity, and so that delicate concentration control of the impurity is enabled.

[0061]

Then, resist masks 304a and 304b are formed thereon, and an impurity element which imparts n-type conductivity (hereafter referred to as an n-type impurity element) is added through the protective film 303. Note that as the n-type impurity element, elements belonging to Group 15 are generally used and typically phosphorus or arsenic can be used. Note that in this embodiment, phosphorus is added at a concentration of 1×10^{18} atoms/cm^3 by using a plasma doping method in which phosphine (PH_3) is plasma excited without mass separation. Of course, an ion implantation method in which mass

separation is performed may also be used.

[0062]

The dosage is adjusted so that n-type impurity regions 305 and 306 formed by this step contain the n-type impurity element at a concentration of 2×10^{16} to 5×10^{19} atoms/cm^3 (typically, 5×10^{17} to 5×10^{18} atoms/cm^3).

[0063]

Next, as shown in FIG. 3C, the protective film 303 is removed, and the added element belonging to Group 15 is activated. A known technique may be used as the activating means, and activation is done in this embodiment by irradiation with excimer laser light. Of course, either a pulsed laser or a continuous wave laser may be used, and it is not necessary to limit to the excimer laser light. However, the object is the activation of the added impurity element, and it is thus preferable that irradiation is performed at an energy level at which the crystalline silicon film does not melt. Note that the laser irradiation may also be performed with the protective film 303 in place.

[0064]

Activation by heat treatment may also be performed along with the activation of the impurity element by laser light. When activation is performed by heat treatment, considering the heat resistance of the substrate, heat treatment may be performed at a temperature of about 450 to 550 °C.

[0065]

This step defines the edges of the n-type impurity regions 305 and 306, namely a boundary portion (connecting portion) with regions on the periphery of the n-type impurity regions 305 and 306, into which the n-type impurity element is not added. This means that, at the point when the TFT is later completed, extremely good connections can be formed between an LDD region and a channel forming region.

[0066]

Next, as shown in FIG. 3D, unnecessary portions of the crystalline silicon film are removed, and island-shaped semiconductor films (hereafter referred to as active layers) 307 to 310 are formed.

[0067]

Then, as shown in FIG. 3E, a gate insulating film 311 is formed to cover the active layers 307 to 310. As the gate insulating film 311, an insulating film containing silicon, which has a thickness of 10 to 200 nm, and preferably 50 to 150 nm, may be used. A single layer structure or a laminated structure may be used. A silicon nitride oxide film with a thickness of 110 nm is used in this embodiment.

[0068]

Next, a conductive film with a thickness of 200 to 400 nm is formed, and patterned to form gate electrodes 312 to 316. The edges of the gate electrodes 312 to 316 can also be formed into a tapered shape. Note that in this embodiment, the gate electrodes and a lead wiring electrically connected to the gate electrodes (hereinafter referred to as a gate wiring) are formed of different materials. Specifically, the gate wiring is formed of a material having a resistance lower than that of the gate electrodes. This is because a material which can be used for microfabrication is used for the gate electrodes, and a material which has a low wiring resistance though cannot be used for microfabrication is used for the gate wiring. Of course, the gate electrodes and the gate wiring may be formed of the same material.

[0069]

Furthermore, although the gate electrodes may be formed of a conductive film of a single layer, it is preferable to make a laminated film such as a two-layer or three-layer film as the need arises. As the material of the gate electrodes, any known conductive

films may be used. However, as described above, it is preferable to use a material which can be used for microfabrication, specifically, can be patterned into a line width of 2 μm or less.

[0070]

Typically, it is possible to use a film made of an element selected from tantalum (Ta), titanium (Ti), molybdenum (Mo), tungsten (W), chromium (Cr), and silicon (Si), a nitride film of the aforementioned elements (typically, a tantalum nitride film, a tungsten nitride film, or a titanium nitride film), an alloy film combining the aforementioned elements (typically, Mo-W alloy, Mo-Ta alloy), or a silicide film of the aforementioned elements (typically, a tungsten silicide film, a titanium silicide film). Of course, the film may be used as a single layer or a laminated layer.

[0071]

In this embodiment, a laminated film of a tungsten nitride (WN) film with a thickness of 50 nm and a tungsten (W) film with a thickness of 350 nm is used. These may be formed by a sputtering method. When an inert gas such as Xe or Ne is added as a sputtering gas, film peeling due to stress can be prevented.

[0072]

The gate electrodes 313 and 316 are formed at this time so as to overlap a portion of the n-type impurity regions 305 and 306 respectively, with the gate insulating film 311 interposed therebetween. These overlapping portions later become LDD regions overlapping the gate electrodes.

[0073]

Next, as shown in FIG. 4A, an n-type impurity element (phosphorus is used in this embodiment) is added in a self-aligning manner with the gate electrodes 312 to 316 used as masks. The addition is adjusted so that phosphorus is added to thus formed

impurity regions 317 to 323 at a concentration of 1/2 to 1/10 (typically, 1/3 to 1/4) of that in the impurity regions 305 and 306. Specifically, a concentration of 1×10^{16} to 5×10^{18} atoms/cm^3 (typically, 3×10^{17} to 3×10^{18} atoms/cm^3) is preferable.

[0074]

Next, as shown in FIG. 4B, resist masks 324a to 324c are formed to cover the gate electrodes and the like, and an n-type impurity element (phosphorus is used in this embodiment) is added, thereby forming impurity regions 325 to 331 containing a high concentration of phosphorus. An ion doping method using phosphine (PH_3) is also performed here, and the phosphorus concentration in these regions is adjusted to 1×10^{20} to 1×10^{21} atoms/cm^3 (typically, 2×10^{20} to 5×10^{21} atoms/cm^3).

[0075]

A source region or a drain region of the n-channel TFT is formed by this step, and in the switching TFT, a portion of the n-type impurity regions 320 to 322 formed by the step of FIG. 4A remains.

[0076]

Next, as shown in FIG. 4C, the resist masks 324a to 324c are removed, and a new resist mask 332 is formed. A p-type impurity element (boron is used in this embodiment) is then added, thereby forming impurity regions 333 and 334 containing a high concentration of boron. Boron is added here at a concentration of 3×10^{20} to 3×10^{21} atoms/cm^3 (typically, 5×10^{20} to 1×10^{21} atoms/cm^3) by an ion doping method using diborane (B_2H_6).

[0077]

Note that phosphorus has already been added to the impurity regions 333 and 334 at a concentration of 1×10^{20} to 1×10^{21} atoms/cm^3; however, boron is added here at a concentration of at least 3 times more than that of the phosphorus. Therefore, the

n-type impurity regions already formed are completely inverted into a p-type, and function as p-type impurity regions.

[0078]

Next, after the resist mask 332 is removed, the n-type or p-type impurity element added at each concentration is activated. As the activating means, a furnace annealing method, a laser annealing method, or a lamp annealing method can be used. In this embodiment, heat treatment in a nitrogen atmosphere at 550 °C for 4 hours is carried out in an electric heating furnace.

[0079]

At this time, it is important to remove oxygen in the atmosphere as much as possible. This is because if oxygen exists even in a small amount, the exposed surface of the gate electrode is oxidized to cause the increase of resistance, and also it becomes difficult to form ohmic contact later. Thus, it is desirable that the oxygen concentration in the treatment atmosphere at the aforementioned activation step is made 1 ppm or less, and preferably 0.1 ppm or less.

[0080]

Next, after the activation step is completed, a gate wiring 335 with a thickness of 300 nm is formed. As a material of the gate wiring 335, a metal film containing aluminum (Al) or copper (Cu) as its main component (constituting 50 to 100 %) may be used. As an arrangement, it is formed so as to electrically connect the gate electrodes 314 and 315 (corresponding to the gate electrodes 19a and 19b of FIG. 3) of the switching TFT like the gate wiring 211 (FIG. 4D).

[0081]

By adopting such a structure, the wiring resistance of the gate wiring can be reduced significantly, so that an image display region (pixel portion) with a large area can

be formed. That is, the pixel structure of this embodiment is very effective in realizing an EL display device having a screen with a diagonal size of 10 inches or more (further, 30 inches or more).

[0082]

Next, as shown in FIG. 5A, a first interlayer insulating film 336 is formed. As the first interlayer insulating film 336, a single layer of an insulating film containing silicon may be used, or a laminated film combining such films may be used. Furthermore, the film thickness may be 400 nm to 1.5 μm. In this embodiment, such a structure is formed that a silicon oxide film with a thickness of 800 nm is laminated on a silicon nitride oxide film with a thickness of 200 nm.

[0083]

In addition, hydrogenation treatment is performed by performing heat treatment at 300 to 450 °C for 1 to 12 hours in an atmosphere containing 3 to 100 % hydrogen. This step is a step of hydrogen terminating the dangling bonds in the semiconductor film with hydrogen which is thermally excited. As another means of hydrogenation, plasma hydrogenation (using hydrogen excited by plasma) may also be performed.

[0084]

Note that the hydrogenation treatment may also be inserted into the formation of the first interlayer insulating film 336. That is, the hydrogenation treatment may be performed as described above after the silicon nitride oxide film is formed to a thickness of 200 nm, and then the remaining silicon oxide film may be formed to a thickness of 800 nm.

[0085]

Next, a contact hole is formed in the first interlayer insulating film 336, and source wirings 337 to 340 and drain wirings 341 to 343 are formed. Note that in this

embodiment, this electrode is made of a laminated film of a three-layer structure in which a Ti film with a thickness of 100 nm, an aluminum film containing Ti with a thickness of 300 nm, and a Ti film with a thickness of 150 nm are continuously formed by a sputtering method. Of course, other conductive films may be used.

[0086]

Next, a first passivation film 344 is formed to a thickness of 50 to 500 nm (typically, 200 to 300 nm). In this embodiment, a silicon nitride oxide film with a thickness of 300 nm is used as the first passivation film 344. This may also be substituted by a silicon nitride film.

[0087]

Note that it is effective to perform plasma treatment using a gas containing hydrogen such as H_2 or NH_3, before the formation of the silicon nitride oxide film. Hydrogen excited by this pretreatment is supplied to the first interlayer insulating film 336, and the film quality of the first passivation film 344 is improved by performing heat treatment. At the same time, hydrogen added to the first interlayer insulating film 336 diffuses to the lower layer side, and therefore the active layers can be hydrogenated effectively.

[0088]

Next, as shown in FIG. 5B, a second interlayer insulating film 345 made of an organic resin is formed. As the organic resin, polyimide, polyamide, acrylic, BCB (benzocyclobutene), or the like can be used. In particular, since the second interlayer insulating film 345 is primarily used for flattening, acrylic with excellent flatness is preferable. In this embodiment, an acrylic film is formed to a thickness sufficient to flatten a stepped portion formed by TFTs. Preferably, the film thickness may be 1 to 5 μm (more preferably, 2 to 4 μm).

[0089]

Next, a contact hole reaching the drain wiring 343 is formed in the second interlayer insulating film 345 and the first passivation film 344, thereby forming a pixel electrode 346. In this embodiment, as the pixel electrode 346, an aluminum alloy film (aluminum film containing titanium of 1 wt%) is formed to a thickness of 300 nm. Note that reference numeral 347 denotes an edge of an adjacent pixel electrode.

[0090]

Next, as shown in FIG. 5C, an alkaline compound 348 is formed. In this embodiment, a lithium fluoride film is formed by an evaporation method to a thickness of 5 nm. Then, an EL layer 349 with a thickness of 100 nm is formed thereon by a spin coating method.

[0091]

As an EL material constituting the EL layer 349, polymer organic materials such as polyparaphenylene vinylene (PPV) or polyfluorene, and low molecular organic materials can be cited. Specifically, as the polymer organic materials exhibiting white light emission, which become a light emitting layer, materials disclosed in Japanese Patent Application Laid-Open No. Hei 8-96959 or No. Hei 9-63770 may be used. For example, it is possible to use a material obtained by dissolving in 1,2-dichloromethane PVK (polyvinylcarbazole), Bu-PBD (2-(4'-*tert*-butylphenyl)-5-(4'-biphenyl)-1,3,4-oxadiazole), coumarin 6, DCM1 (4-dicyanomethylene-2-methyl-6-p-dimethylaminostyryl-4H-pyrane), TPB (tetraphenylbutadiene), or Nile red. At this time, the film thickness may be 30 to 150 nm (preferably, 40 to 100 nm). The above example is merely an example of organic materials which can be used for the EL layer of the present invention, and does not limit the present invention.

[0092]

Besides, as described above, there are roughly four colorizing systems, and in this embodiment, a system of forming color filters corresponding to RGB was used for colorization. As the EL layer 349, a known material and structure may be used; in the present invention, a low molecular organic material capable of emitting white light was used. Note that the color filters corresponding to RGB may be positioned above the pixel electrodes on the active matrix substrate. Alternatively, such a structure may be adopted that another substrate is bonded to the active matrix substrate so as to seal the EL element, and the color filters are provided on that substrate. Note that the color filters are not shown for simplification.

[0093]

Alternatively, it is also possible to adopt a color display system in which an EL layer of blue or blue-green light emission and a fluorescent material (fluorescent color conversion layer: CCM) are combined, or a system in which color display is made by stacking EL layers corresponding to RGB.

[0094]

Note that in this embodiment, the EL layer 349 has a single layer structure of only the aforementioned light emitting layer; however, an electron injecting layer, an electron transporting layer, a hole transporting layer, a hole injecting layer, an electron blocking layer, or a hole blocking layer may be provided as the need arises.

[0095]

Next, an anode 350 with a thickness of 200 nm is formed of a transparent conductive film to cover the EL layer 349. In this embodiment, a film made of a compound of indium oxide and zinc oxide is formed by an evaporation method, and patterning is carried out to make the anode.

[0096]

Finally, a second passivation film 351 made of a silicon nitride film is formed by a plasma CVD method to a thickness of 100 nm. This second passivation film 351 protects the EL layer 349 from moisture or the like. Besides, it also serves to release heat generated in the EL layer 349. In order to further increase the heat dissipation effect, it is also effective to laminate a silicon nitride film and a carbon film (preferably, a diamond-like carbon film) to make the second passivation film.

[0097]

In this way, an active matrix EL display device having such a structure as shown in FIG. 5C is completed. Then, in the active matrix EL display device of this embodiment, a TFT having an optimum structure is disposed not only in the pixel portion but also in the driver circuit portion, so that very high reliability is obtained and operation characteristics can also be improved.

[0098]

First, a TFT having a structure to reduce hot carrier injection so as not to decrease the operation speed as much as possible is used as an n-channel TFT of a CMOS circuit forming a driver circuit. Note that the driver circuit here includes a shift register, a buffer, a level shifter, a sampling circuit (a sample and hold circuit), and the like. In the case where digital driving is performed, a signal conversion circuit such as a D/A converter can also be included.

[0099]

In the case of this embodiment, as shown in FIG. 6C, the active layer of the n-channel TFT includes a source region 355, a drain region 356, an LDD region 357, and a channel formation region 358, and the LDD region 357 overlaps the gate electrode 313 with the gate insulating film 311 interposed therebetween.

[0100]

The reason why the LDD region is formed on only the drain region side is not to decrease the operation speed. In addition, it is not necessary to pay much attention to the off current value of this n-channel TFT, and it is better to give importance to an operation speed. Thus, it is desirable that the LDD region 357 completely overlap the gate electrode to decrease a resistance component to a minimum. That is, a so-called offset is preferably removed.

[0101]

Furthermore, in the p-channel TFT of the CMOS circuit, deterioration due to hot carrier injection hardly becomes a problem; thus, an LDD region does not need to be particularly provided. Of course, an LDD region may be provided similarly to in the n-channel TFT to take a hot carrier countermeasure.

[0102]

Note that, among the driver circuits, the sampling circuit is somewhat unique compared to the other circuits, in that a large current flows in both directions in the channel forming region. That is, the roles of the source region and the drain region are interchanged. In addition, it is necessary to keep the off current value as small as possible, and it is thus desirable to dispose a TFT having a function intermediate between those of the switching TFT and the current control TFT.

[0103]

Note that the aforementioned structure can be easily realized by manufacturing TFTs in accordance with the manufacturing steps shown in FIGS. 3 to 5. In addition, although only the structures of the pixel portion and the driver circuit are shown in this embodiment, if the manufacturing steps of this embodiment are used, logic circuits other than the driver circuit, such as a signal dividing circuit, a D/A conversion circuit, or an

operational amplifier circuit can be formed on the same substrate, and it is further thought that a memory portion, a microprocessor, or the like can be formed.

[0104]

After the process up to FIG. 5C is completed, a sealing material (also referred to as a housing material) 18 is formed so as to surround at least the pixel portion, and preferably the driver circuits and the pixel portion (FIG. 6). Note that as the sealing material 18, a glass plate having a concave portion so as to surround the element portion may be used or an ultraviolet curable resin may also be used. At this time, the EL element is in a state of being completely enclosed in the aforementioned airtight space, and is completely cut off from the air.

[0105]

Furthermore, a gap 20 between the sealing material 18 and the substrate 10 is desirably filled with an inert gas (argon, helium, nitrogen, or the like) or provided with a drying agent such as barium oxide. This makes it possible to suppress deterioration of the EL element due to moisture or the like.

[0106]

Besides, after the sealing treatment of the EL layer is completed, a connector (flexible printed circuit: FPC 17) for connecting a terminal extended from an element or a circuit formed on the substrate to an external signal terminal is attached so that a product is completed. Note that as shown in FIG. 6, a wiring 26 is electrically connected to the FPC 17 through the gap (which is filled with an adhesive 19) between the sealing material 18 and the substrate 300.

[0107]

Here, the structure of an active matrix EL display device of this embodiment is described with reference to a top view of FIG. 7. In FIG. 7, reference numeral 300

denotes a substrate; 11, a pixel portion; 12, a source line side driver circuit; and 13, a gate line side driver circuit. The respective driver circuits reach an FPC 17 through wirings 14 to 16 and are connected to external equipment.

[0108]

In the aforementioned state shown in FIG. 7, an image can be displayed on the pixel portion by connecting the FPC 17 to a terminal of the external equipment. In the present specification, an article which is brought into a state where image display can be made by attaching an FPC is defined as an EL display device.

[0109]

Note that although an example in which output light of the EL element is outputted to the upper surface side of the active matrix substrate was shown in this embodiment, such a structure may be adopted that an EL element includes a pixel electrode (anode) made of ITO / an EL layer / an MgAg electrode (cathode) in order from the bottom. In this case, output light of the EL element is outputted to the substrate side in which TFTs are formed (lower surface side of the active matrix substrate).

[0110]

[Embodiment 2]

In Embodiment 1, the example in which the low molecular organic material exhibiting white light emission is used as the EL material constituting the EL layer was described. In this embodiment, an example in which three kinds of polymer organic material layers corresponding to R (red), G (green) and B (blue) are stacked is described. Note that since this embodiment is different from Embodiment 1 only in the EL materials, description is made only on that point.

[0111]

Instead of the low molecular organic material shown in Embodiment 1, polymer

organic materials (polyparaphenylene vinylene (PPV), polyfluorene, or the like) may be used. For example, cyanopolyphenylenevinylene was used for a red light emitting material, polyphenylenevinylene was used for a green light emitting material, and polyphenylenevinylene and polyalkylphenylene were used for a blue light emitting material.

[0112]

By adopting such a structure, light emission (red light emission, green light emission, and blue light emission) with high luminance can be obtained.

[0113]

[Embodiment 3]

Laser crystallization is used as the means of forming the crystalline silicon film 302 in Embodiment 1. In this embodiment, a case of using a different means of crystallization is explained.

[0114]

In this embodiment, after forming an amorphous silicon film, crystallization is performed using the technique disclosed in Japanese Patent Application Laid-Open No. Hei 7-130652. The technique disclosed in this patent application is one of obtaining a crystalline silicon film having good crystallinity by using an element such as nickel as a catalyst for promoting (helping) crystallization.

[0115]

Furthermore, after the crystallization step is completed, a step of removing the catalyst used in the crystallization may be performed. In this case, the catalyst may be gettered using the technique disclosed in Japanese Patent Application Laid-Open No. Hei 10-270363 or Japanese Patent Application Laid-Open No. Hei 8-330602.

[0116]

Alternatively, a TFT may be formed using the technique disclosed in the specification of Japanese Patent Application No. Hei 11-076967 by the present applicant.

[0117]

As set forth above, the manufacturing steps shown in Embodiment 1 are one embodiment, and other manufacturing steps may also be used without any problems as long as the structure of FIG. 5C of Embodiment 1 can be realized. Note that the structure of this embodiment can be freely combined with the structure of Embodiment 2.

[0118]

[Embodiment 4]

The case of using a top gate type TFT was explained in Embodiment 1; however, the present invention is not limited to a TFT structure and may also be implemented using a bottom gate type TFT (typically, an inverted stagger type TFT). Furthermore, the inverted stagger type TFT may be formed by any means.

[0119]

The inverted stager type TFT has a structure in which the number of steps can be easily reduced as compared to the top gate type TFT, which is extremely advantageous in lowering manufacturing costs, an object of the present invention. Note that the structure of this embodiment can be freely combined with the structure of Embodiment 2 or Embodiment 3.

[0120]

[Embodiment 5]

The EL display device fabricated in accordance with the present invention is of a self-emission type, and thus has superior visibility in a light place and has a wider viewing angle as compared to the liquid crystal display device. Accordingly, the EL display device can be used as a display portion of various electronic devices. For

example, in order to watch a TV program or the like on a large-sized screen, the EL display device of the present invention can be used as a display portion of an EL display (a display in which an EL display device is installed into a housing) having a diagonal size of 30 inches or more (typically, 40 inches or more).

[0121]

The EL display includes all kinds of displays to be used for displaying information, such as a display for a personal computer, a display for receiving a TV broadcasting program, or a display for advertisement display. Moreover, the EL display device of the present invention can be used as a display portion of other various electric devices.

[0122]

As such electronic devices, a video camera, a digital camera, a goggle type display (head mounted display), a car navigation system, a car audio system, a laptop personal computer, a game machine, a portable information terminal (a mobile computer, a cellular phone, a portable game machine, an electronic book, or the like), an image reproduction apparatus provided with a recording medium (specifically, an apparatus which can reproduce a recording medium such as a compact disc (CD), a laser disc (LD), or a digital video disc (DVD), and includes a display for displaying the reproduced image), and the like can be cited. In particular, the EL display device is desirably used for the portable information terminal which is often viewed from an oblique direction and is required to have a wide viewing angle. FIG. 8 shows specific examples of such electronic devices.

[0123]

FIG. 8A is an EL display which includes a housing 2001, a support table 2002, a display portion 2003, and the like. The present invention is applicable to the display

portion 2003. The EL display is of a self-emission type and therefore requires no back light. Thus, the display portion thereof can have a thickness smaller than that of the liquid crystal display.

[0124]

FIG. 8B is a video camera which includes a main body 2101, a display portion 2102, an audio input portion 2103, operation switches 2104, a battery 2105, an image receiving portion 2106, and the like. The EL display device of the present invention can be used as the display portion 2102.

[0125]

FIG. 8C is a portion (right side) of a head mounted type EL display, which includes a main body 2201, signal cables 2202, a head mounted band 2203, a display portion 2204, an optical system 2205, an EL display device 2206, and the like. The present invention is applicable to the EL display device 2206.

[0126]

FIG. 8D is an image reproduction apparatus provided with a recording medium (specifically, a DVD reproduction apparatus), which includes a main body 2301, a recording medium (a CD, an LD, a DVD or the like) 2302, operation switches 2303, a display portion (a) 2304, a display portion (b) 2305, and the like. The display portion (a) mainly displays image information, while the display portion (b) mainly displays character information. The EL display device of the present invention can be used as these display portions (a) and (b). The image reproduction apparatus provided with a recording medium may also include a CD reproduction apparatus, a game machine or the like.

[0127]

FIG. 8E is a portable (mobile) computer which includes a main body 2401, a

camera portion 2402, an image receiving portion 2403, an operation switch 2404, a display portion 2405, and the like. The EL display device of the present invention can be used as the display portion 2405.

[0128]

FIG. 8F is a personal computer which includes a main body 2501, a housing 2502, a display portion 2503, a keyboard 2504, and the like. The EL display device of the present invention can be used as the display portion 2503.

[0129]

Note that when the luminance of EL materials increases in the future, they can be applicable to a front-type or rear-type projector in which light including output image information is enlarged by means of lenses or the like to be projected.

[0130]

Furthermore, in the EL display device, a light emitting portion consumes power, and it is thus desirable to display information so that the light emitting portion becomes as small as possible. Accordingly, when the EL display device is applied to a display portion which mainly displays character information, e.g., a display portion of a portable information terminal, particularly of a cellular phone or a car audio system, it is desirable to drive the EL display device so that the character information is formed by a light emitting portion while a non-emission portion is used as the background.

[0131]

Now, FIG. 9A is a cellular phone which includes a main body 2601, an audio output portion 2602, an audio input portion 2603, a display portion 2604, operation switches 2605, and an antenna 2606. The EL display device of the present invention can be used as the display portion 2604. Note that the power consumption of the cellular phone can be reduced by displaying white-colored characters on a black-colored

background in the display portion 2604.

[0132]

FIG. 9B is a car audio system which includes a main body 2701, a display portion 2702, and operation switches 2703 and 2704. The EL display device of the present invention can be used as the display portion 2702. Although the in-car audio system is shown in this embodiment, the present invention may be used for an installed car audio system. Note that the power consumption can be reduced by displaying white-colored characters on a black-colored background in the display portion 2704, which is particularly advantageous for the installed car audio system.

[0133]

As set forth above, the application range of the present invention is so wide that the present invention can be used for electronic devices in all fields. The electronic devices of this embodiment can be obtained by utilizing an EL display device in which the structures of Embodiments 1 to 4 are freely combined.

[0134]

[Effect of the Invention]

In the present invention, by providing the means for gamma correcting a signal applied to a pixel of an EL display device, the EL display device including an EL element emitting light with a suitably controlled luminance is manufactured.

[0135]

Furthermore, by using the EL display device of the present invention as a display portion, an inexpensive electronic device with high visibility can be obtained.

[Brief Description of the Drawings]

[FIG. 1] a circuit block diagram of the EL display device of the present invention

[FIG. 2] a structural diagram in generating a gamma correction table of the EL display device of the present invention

[FIG. 3] views showing manufacturing steps of an active matrix EL display device

[FIG. 4] views showing manufacturing steps of an active matrix EL display device

[FIG. 5] views showing manufacturing steps of an active matrix EL display device

[FIG. 6] a cross sectional view of an EL display device

[FIG. 7] a top view of an EL display device

[FIG. 8] views showing examples of electronic devices

[FIG. 9] views showing examples of electronic devices

[FIG. 10] diagram showing characteristics of the luminance and current density of EL elements (R, G, B)

[Document Name] Abstract

[Summary]

[Problem] It is to provide in an EL display device in which the color purity of each of red, blue and green is different, the EL display device displaying an image having a desirable good balance between red, blue and green.

[Solving Means] A video signal supplied to each EL element is gamma corrected by a correction circuit 161, the color purity of each of blue light emission, green light emission, and red light emission is appropriately controlled in accordance with the voltage and current of the corrected video signal.

[Selected Drawing] FIG. 1